

EXHIBIT 8



US010409510B2

(12) **United States Patent**
Tzannes et al.

(10) **Patent No.: US 10,409,510 B2**

(45) **Date of Patent: Sep. 10, 2019**

(54) **RESOURCE SHARING IN A
TELECOMMUNICATIONS ENVIRONMENT**

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,439,859 A 3/1984 Donnan
4,564,900 A 1/1986 Smitt
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1350297 A 5/2002
CN 1352862 A 6/2002
(Continued)

OTHER PUBLICATIONS

European Search Report for European Application No. 18153945.3,
dated May 3, 2018.

(Continued)

(71) Applicant: **TQ DELTA, LLC**, Austin, TX (US)

(72) Inventors: **Marcos C. Tzannes**, Petaluma, CA
(US); **Michael Lund**, West Newton,
MA (US)

(73) Assignee: **TQ DELTA, LLC**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/874,277**

(22) Filed: **Jan. 18, 2018**

(65) **Prior Publication Data**

US 2018/0157436 A1 Jun. 7, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/372,841, filed on
Dec. 8, 2016, now Pat. No. 9,898,220, which is a
(Continued)

(51) **Int. Cl.**
G06F 3/06 (2006.01)
H04L 1/18 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **G06F 3/0631** (2013.01); **G06F 3/0611**
(2013.01); **G06F 3/0644** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 3/0631; G06F 3/0611; G06F 3/0644;
G06F 3/0659; G06F 3/0665;
(Continued)

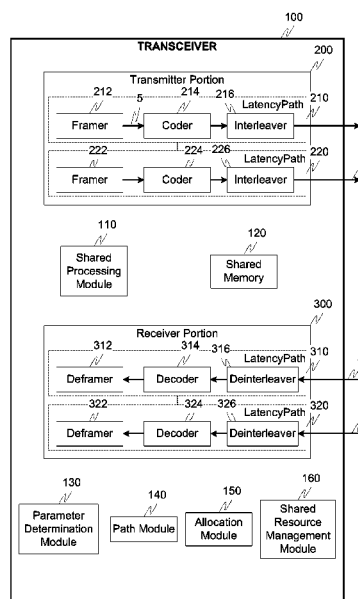
Primary Examiner — John J Tabone, Jr.

(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan
Ross, PC

(57) **ABSTRACT**

A transceiver is designed to share memory and processing power amongst a plurality of transmitter and/or receiver latency paths, in a communications transceiver that carries or supports multiple applications. For example, the transmitter and/or receiver latency paths of the transceiver can share an interleaver/deinterleaver memory. This allocation can be done based on the data rate, latency, BER, impulse noise protection requirements of the application, data or information being transported over each latency path, or in general any parameter associated with the communications system.

24 Claims, 3 Drawing Sheets



US 10,409,510 B2

Page 2

Related U.S. Application Data

continuation of application No. 15/046,821, filed on Feb. 18, 2016, now Pat. No. 9,547,608, which is a continuation of application No. 14/730,874, filed on Jun. 4, 2015, now Pat. No. 9,286,251, which is a continuation of application No. 14/081,469, filed on Nov. 15, 2013, now Pat. No. 9,069,718, which is a continuation of application No. 13/942,938, filed on Jul. 16, 2013, now Pat. No. 8,607,126, which is a continuation of application No. 13/567,261, filed on Aug. 6, 2012, now Pat. No. 8,495,473, which is a continuation of application No. 12/901,699, filed on Oct. 11, 2010, now Pat. No. 8,276,048, which is a continuation of application No. 12/761,586, filed on Apr. 16, 2010, now Pat. No. 7,844,882, which is a continuation of application No. 11/246,163, filed on Oct. 11, 2005, now Pat. No. 7,831,890.

- (60) Provisional application No. 60/618,269, filed on Oct. 12, 2004.

(51) Int. Cl.

H04L 12/54 (2013.01)
H04L 12/701 (2013.01)
H04L 12/721 (2013.01)
H04L 12/801 (2013.01)
H04L 1/00 (2006.01)
H04L 27/26 (2006.01)
H04L 12/861 (2013.01)
H04L 12/879 (2013.01)
H04B 1/38 (2015.01)
G06F 13/16 (2006.01)

(52) U.S. Cl.

CPC *G06F 3/0659* (2013.01); *G06F 3/0665* (2013.01); *G06F 3/0673* (2013.01); *G06F 13/1647* (2013.01); *H04B 1/38* (2013.01); *H04L 1/0041* (2013.01); *H04L 1/0071* (2013.01); *H04L 1/1809* (2013.01); *H04L 1/1835* (2013.01); *H04L 1/1874* (2013.01); *H04L 12/5601* (2013.01); *H04L 27/2601* (2013.01); *H04L 45/00* (2013.01); *H04L 45/72* (2013.01); *H04L 47/10* (2013.01); *H04L 49/90* (2013.01); *H04L 49/901* (2013.01); *H04L 1/0045* (2013.01); *H04L 1/0057* (2013.01)

(58) Field of Classification Search

CPC *G06F 3/0673*; *G06F 13/1647*; *H04B 1/38*; *H04L 1/0041*; *H04L 1/0071*; *H04L 1/1809*; *H04L 1/1835*; *H04L 1/1874*; *H04L 12/5601*; *H04L 27/2601*; *H04L 45/00*; *H04L 45/72*; *H04L 47/10*; *H04L 49/90*; *H04L 49/901*; *H04L 1/0045*; *H04L 1/0057*
 USPC 714/704, 748, 776, 774, 784, 147, 153, 714/157, 173; 375/222; 379/93.01; 709/215

See application file for complete search history.

(56) References Cited

U.S. PATENT DOCUMENTS

4,914,653 A 4/1990 Bishop et al.
 4,979,174 A 12/1990 Cheng et al.
 5,063,533 A 11/1991 Erhart et al.
 5,214,501 A 5/1993 Cavallerano et al.
 5,287,384 A 2/1994 Avery et al.
 5,319,648 A 6/1994 Bux et al.

5,351,016 A 9/1994 Dent
 5,420,640 A 5/1995 Munich et al.
 5,422,913 A 6/1995 Wilkinson
 5,524,116 A 6/1996 Kalmanek, Jr. et al.
 5,563,915 A 10/1996 Stewart
 5,596,604 A 1/1997 Cioffi et al.
 5,635,864 A 6/1997 Jones
 5,663,910 A 9/1997 Ko et al.
 5,675,585 A 10/1997 Bonnot et al.
 5,726,644 A 3/1998 Jednacz et al.
 5,737,337 A 4/1998 Voith et al.
 5,745,275 A 4/1998 Giles et al.
 5,751,338 A 5/1998 Ludwig, Jr.
 5,751,741 A 5/1998 Voith et al.
 5,757,416 A 5/1998 Birch et al.
 5,764,649 A 6/1998 Tong
 5,764,693 A 6/1998 Taylor et al.
 5,793,759 A 8/1998 Rakib et al.
 5,835,527 A 11/1998 Lomp
 5,867,400 A 2/1999 El-Ghoroury et al.
 5,898,698 A 4/1999 Bross
 5,903,612 A 5/1999 Van Der Puttent et al.
 5,905,874 A 5/1999 Johnson
 5,912,898 A 6/1999 Khoury
 5,917,340 A 6/1999 Manohar et al.
 5,968,200 A 10/1999 Amrany
 5,983,382 A 11/1999 Pauls
 5,991,857 A 11/1999 Koetje et al.
 5,995,539 A 11/1999 Miller
 6,005,851 A 12/1999 Craddock et al.
 6,041,057 A 3/2000 Stone
 6,081,291 A 6/2000 Ludwig, Jr.
 6,098,188 A 8/2000 Kalmanek, Jr. et al.
 6,151,690 A 11/2000 Peeters
 6,212,166 B1 4/2001 Akiyama et al.
 6,226,322 B1 5/2001 Mukherjee
 6,266,337 B1 6/2001 Marco
 6,285,665 B1 9/2001 Chuah
 6,308,278 B1 10/2001 Khouli et al.
 6,337,877 B1 1/2002 Cole et al.
 6,381,728 B1 4/2002 Kang
 6,392,572 B1 5/2002 Shiu et al.
 6,421,323 B1 7/2002 Nelson et al.
 6,473,418 B1 10/2002 Laroia et al.
 6,480,976 B1 11/2002 Pan et al.
 6,484,283 B2 11/2002 Stephen et al.
 6,496,481 B1 12/2002 Wu et al.
 6,498,806 B1 12/2002 Davis
 6,519,731 B1 2/2003 Huang et al.
 6,542,500 B1 4/2003 Gerszberg et al.
 6,553,534 B2 4/2003 Young, III et al.
 6,578,162 B1 6/2003 Yung
 6,640,239 B1 10/2003 Gidwani
 6,657,949 B1 12/2003 Jones, IV et al.
 6,704,848 B2 3/2004 Song
 6,707,822 B1 * 3/2004 Fadavi-Ardekani H04L 5/14 370/395.5
 6,738,370 B2 5/2004 Ostman
 6,754,188 B1 6/2004 Garahi et al.
 6,754,290 B1 6/2004 Halter
 6,765,957 B2 7/2004 Palm
 6,775,320 B1 8/2004 Tzannes et al.
 6,778,589 B1 8/2004 Ishii
 6,778,596 B1 8/2004 Tzannes
 6,801,570 B2 * 10/2004 Yong H04L 1/0009 375/219
 6,826,589 B2 11/2004 Berrada
 6,865,233 B1 3/2005 Eriksson et al.
 6,885,696 B2 4/2005 Wingrove
 6,904,537 B1 6/2005 Gorman
 6,922,444 B1 7/2005 Cai et al.
 6,956,872 B1 10/2005 Djokovic et al.
 6,988,234 B2 1/2006 Han
 7,024,592 B1 4/2006 Voas et al.
 7,027,782 B2 4/2006 Moon et al.
 7,031,259 B1 4/2006 Guttman et al.
 7,042,891 B2 * 5/2006 Oberman H04L 49/25 370/230
 7,050,552 B2 5/2006 Comisky

US 10,409,510 B2

Page 3

(56)

References Cited

U.S. PATENT DOCUMENTS

7,058,085 B2 6/2006 Earnshaw et al.
 7,103,096 B2 9/2006 Mitlin et al.
 7,164,654 B2 1/2007 Hunzinger et al.
 7,174,493 B2 2/2007 Matsumoto et al.
 7,187,708 B1 3/2007 Shiu et al.
 7,200,138 B2 4/2007 Liu
 7,200,169 B2 4/2007 Suzuki et al.
 7,200,792 B2 4/2007 Kim et al.
 7,203,206 B2 4/2007 Amidan et al.
 7,224,702 B2 5/2007 Lee
 7,266,132 B1 9/2007 Liu et al.
 7,269,208 B2 9/2007 Mazzoni et al.
 7,272,768 B2 9/2007 Chang et al.
 7,302,379 B2 11/2007 Cioffi et al.
 7,400,688 B2 7/2008 Garrett
 7,483,421 B2 1/2009 Compton
 7,519,124 B2* 4/2009 Oksman H04L 1/0006
 370/395.64
 7,600,172 B2 10/2009 Berens et al.
 7,657,818 B2* 2/2010 Cioffi H03M 13/2732
 714/755
 7,668,101 B1 2/2010 Raissinia et al.
 7,764,595 B2 7/2010 Treigherman
 7,782,758 B2 8/2010 Wydrowski et al.
 7,826,438 B1 11/2010 Salhotra et al.
 7,831,890 B2* 11/2010 Tzannes H04L 1/0041
 375/222
 7,836,381 B1* 11/2010 Tzannes H04L 1/0041
 375/222
 7,844,882 B2* 11/2010 Tzannes H04L 1/0041
 375/222
 7,856,033 B2* 12/2010 Oksman H04L 5/1446
 370/465
 7,933,295 B2 4/2011 Thi et al.
 8,031,760 B2* 10/2011 Peeters H04L 1/0025
 375/222
 8,074,138 B2 12/2011 Chae et al.
 8,098,613 B2 1/2012 Bi et al.
 8,149,904 B2* 4/2012 Efland G06F 9/52
 375/222
 8,276,048 B2 9/2012 Tzannes et al.
 8,335,956 B2 12/2012 Tzannes
 8,407,546 B2 3/2013 Tzannes
 8,468,411 B2 6/2013 Tzannes
 8,495,473 B2* 7/2013 Tzannes H04L 1/0041
 375/222
 8,595,577 B2 11/2013 Tzannes
 8,607,126 B1* 12/2013 Tzannes H04L 1/0041
 375/222
 8,645,784 B2 2/2014 Tzannes
 8,775,890 B2 7/2014 Yap et al.
 9,069,718 B2 6/2015 Tzannes et al.
 9,094,348 B2 7/2015 Tzannes
 9,286,251 B2* 3/2016 Tzannes H04L 1/0041
 9,485,055 B2 11/2016 Tzannes
 9,547,608 B2 1/2017 Tzannes et al.
 9,749,235 B2 8/2017 Tzannes
 9,898,220 B2 2/2018 Tzannes et al.
 2001/0014962 A1 8/2001 Obuchi et al.
 2001/0031011 A1 10/2001 Betts
 2001/0039637 A1 11/2001 Bengough
 2002/0015401 A1 2/2002 Subramanian et al.
 2002/0048365 A1 4/2002 Namiki et al.
 2002/0087710 A1 7/2002 Aiken et al.
 2002/0126675 A1 9/2002 Yoshimura et al.
 2002/0154600 A1 10/2002 Ido et al.
 2003/0005387 A1 1/2003 Tsunoda
 2003/0008821 A1 1/2003 Detmar et al.
 2003/0009717 A1 1/2003 Fukushima et al.
 2003/0014709 A1 1/2003 Miyoshi et al.
 2003/0053435 A1* 3/2003 Sindhushayana H04L 1/0003
 370/342
 2003/0067877 A1 4/2003 Sivakumar et al.
 2003/0076870 A1 4/2003 Moon et al.

2003/0088821 A1 5/2003 Yokokawa et al.
 2003/0093750 A1 5/2003 Cameron
 2003/0097629 A1 5/2003 Moon et al.
 2003/0118031 A1 6/2003 Classon et al.
 2003/0131209 A1 7/2003 Lee
 2003/0179770 A1 9/2003 Reznic et al.
 2004/0013195 A1 1/2004 Panusopone et al.
 2004/0109455 A1 6/2004 Jouppe et al.
 2004/0114536 A1 6/2004 O'Rourke
 2004/0120435 A1 6/2004 Yang et al.
 2004/0148552 A1 7/2004 Matsumoto et al.
 2004/0174938 A1 9/2004 Kim
 2004/0179494 A1 9/2004 Attar et al.
 2004/0196786 A1 10/2004 Laha et al.
 2004/0203455 A1 10/2004 Bao et al.
 2004/0203723 A1 10/2004 Han
 2005/0034046 A1 2/2005 Berkmann et al.
 2005/0036497 A1 2/2005 Kawakami
 2005/0068916 A1 3/2005 Jacobsen et al.
 2005/0079889 A1 4/2005 Vaglica et al.
 2005/0180323 A1 8/2005 Beightol et al.
 2005/0204251 A1 9/2005 Moon et al.
 2005/0216812 A1 9/2005 Leon et al.
 2005/0254441 A1 11/2005 Levi et al.
 2005/0254508 A1 11/2005 Aksu et al.
 2006/0088054 A1* 4/2006 Tzannes H04L 1/0041
 370/468
 2006/0089833 A1 4/2006 Su et al.
 2006/0092871 A1 5/2006 Nishibayashi et al.
 2006/0098662 A1 5/2006 Gupta et al.
 2006/0112168 A1 5/2006 Albers et al.
 2006/0236045 A1* 10/2006 Keyes, Jr. H04L 12/66
 711/157
 2006/0242153 A1 10/2006 Newberry et al.
 2006/0259846 A1* 11/2006 Bhushan H03M 13/276
 714/755
 2007/0198898 A1 8/2007 Ysebaert et al.
 2007/0206621 A1 9/2007 Plamondon et al.
 2007/0263528 A1 11/2007 Mukherjee
 2008/0077837 A1 3/2008 Lohr et al.
 2008/0175186 A1 7/2008 Liu et al.
 2008/0212582 A1 9/2008 Zwart et al.
 2009/0013232 A1 1/2009 Wan et al.
 2009/0217120 A1 8/2009 Sawahashi et al.
 2009/0300450 A1* 12/2009 Tzannes H04L 12/5601
 714/748
 2009/0300468 A1 12/2009 Pekonen
 2009/0319854 A1 12/2009 Qian et al.
 2009/0327829 A1 12/2009 Yang et al.
 2010/0061376 A1 3/2010 Shimizu
 2010/0228924 A1* 9/2010 Tzannes H04L 1/0041
 711/147
 2011/0002331 A1* 1/2011 Tzannes H04L 12/5601
 370/389
 2011/0029844 A1* 2/2011 Tzannes H04L 1/0041
 714/774
 2012/0297148 A1* 11/2012 Tzannes H04L 1/0041
 711/147
 2014/0075128 A1* 3/2014 Tzannes H04L 1/0041
 711/147
 2015/0268863 A1* 9/2015 Tzannes H04L 1/0041
 711/153
 2016/0179389 A1* 6/2016 Tzannes H04L 1/0041
 711/153
 2017/0041224 A1 2/2017 Tzannes
 2017/0090811 A1* 3/2017 Tzannes G06F 3/0631
 2017/0373971 A1 12/2017 Tzannes

FOREIGN PATENT DOCUMENTS

CN 1527487 A 9/2004
 EP 0833474 A2 4/1998
 EP 1006689 6/2000
 EP 1041756 10/2000
 EP 1225735 7/2002
 EP 1246409 10/2002
 EP 1271833 1/2003
 EP 1361690 11/2003

US 10,409,510 B2

Page 4

(56)

References Cited

FOREIGN PATENT DOCUMENTS

EP	1385292	1/2004
EP	1507353	2/2005
EP	1367809	1/2006
GB	2389493	12/2003
JP	06-164648	6/1994
JP	07-254862	10/1995
JP	Hei09-247048	9/1997
JP	Hei11-150764	6/1999
JP	Hei11-355254 A	12/1999
JP	2000-341247	12/2000
JP	2001-119437	4/2001
JP	2002-084338	3/2002
JP	2002-118527	4/2002
JP	2003-008553	1/2003
JP	2003-509966	3/2003
JP	2003-224615	8/2003
JP	2004-007269	1/2004
JP	2004-007823	1/2004
JP	2004-030506	1/2004
JP	2004-056221	2/2004
JP	2004-135013	4/2004
JP	2005-064594	3/2005
JP	2005-191735	7/2005
JP	2005-522963	7/2005
JP	2005-526422	9/2005
KR	2000-0016939	3/2000
KR	10-2000-0047827	7/2000
KR	10-0295086 B1	4/2001
KR	2001-0077300	8/2001
KR	10-2004-0009928	1/2004
KR	10-2004-0014977	2/2004
WO	WO 98/47238	10/1998
WO	WO 00/41395	7/2000
WO	WO 00/42789	7/2000
WO	WO 00/52834	9/2000
WO	WO 01/11833	2/2001
WO	WO 01/20865	3/2001
WO	WO 03/003747	1/2003
WO	WO 03/028296	4/2003
WO	WO 03/063060	7/2003
WO	WO 03/090011	10/2003

OTHER PUBLICATIONS

Intention to Grant for European Patent Application No. 17020026.5 dated Jun. 13, 2018.

U.S. Appl. No. 60/078,549, filed Mar. 19, 1998, Jacobsen et al. Aramvith, Supavadee et al. "Wireless Video Transport Using Conditional Retransmission and Low-Delay Interleaving" IEEE 2001 (4 pages).

Bauer, Rainer et al. "Iterative Source/Channel-Decoding Using Reversible Variable Length Codes" Munich University of Technology, 2000 (10 pages).

Business Wire "New FatPipe T1 Speed Product Produces Speeds up to 4.5Mbps and Redundancy for a Fraction of the Cost of a Fractional T3!" Business Wire, Oct. 16, 1998 (2 pages).

Buzzard, Greg et al., "An Implementation of the Hamlyn Sender-Managed Interface Architecture" The Second Symposium on Operating Systems Design and Implementation (OSDI '96) Proceedings (Seattle, WA), Oct. 28-31, 1996 (15 pages).

Cisco Systems, Inc. "Alternatives for High Bandwidth Connections Using Parallel T1/E1 Links" 1998 (8 pages).

Eberle, Wolfgang et al. "80-Mb/s QPSK and 72-Mb/s 64-QAM Flexible and Scalable Digital OFDM Transceiver ASICs for Wireless Local Area Networks in the 5-GHz Band" IEEE Journal of Solid-State Circuits, vol. 36, No. 11, Nov. 2001 (10 pages).

Goodman, David et al. "Maximizing the Throughput to CDMA Data Communications" Polytechnic University, Brooklyn, NY, Oct. 2003 (5 pages).

"ITU-T Recommendation G.992.1, Series G: Transmission Systems and Media, Digital Systems and Networks" Jun. 1999 (256 pages).

"ITU-T Recommendation G.992.3," International Telecommunication Union, ADSL2, Jan. 2005, 436 pages.

ITU-T Recommendation G.992.3, "Asymmetric Digital Subscriber Line Transceivers 2 (ADSL2)" International Telecommunication Union, Apr. 2009, 404 pages.

ITU-T Recommendation G.992.3 Annex C, "Annex C: Specific Requirements for an ADSL System Operating in the Same Cable as ISDN as Defined in Appendix III of Recommendation ITU-T G.961" International Telecommunication Union, Apr. 2009, 296 pages.

"ITU-T Recommendation G.992.5—Series G: Transmission Systems and Media, Digital Systems and Networks", International Telecommunication Union, ADSL2, May 2003, 92 pages.

ITU-T Recommendation G.993.1 "Very High Speed Digital Subscriber Line Transceivers" Jun. 2004 (228 pages).

ITU-Telecommunication Standardization Sector; Study Group 15; Alcatel; "G.gen: A Hybrid PCTCM-ARQ Error Correction Scheme" Temporary Document HC-52; Huntsville, Canada; Aug. 2000 (6 pages).

ITU-T SG15/Q4 Contribution LB-031 "VDSL2—Constraining the Interleaver Complexity" Texas Instruments, Inc. Jun. 2004 (7 pages). Johns, David A., et al. "Integrated Circuits for Data Transmission Over Twisted-Pair Channels" IEEE Journal of Solid-State Circuits, vol. 32, Nov. 3, Mar. 1997 (9 pages).

Petzold, Mark C. et al. "Multicarrier Spread Spectrum Performance in Fading Channels with Serial Concatenated Convolutional Coding" IEEE 1998 (4 pages).

Shoji, T. et al. "Wireless Access Method to Ensure Each Users QOS in Unpredictable and Various QOS Requirements Wireless Personal Communications," Springer, Dordrecht, NL, vol. 22, No. 2, Aug. 2002, pp. 139-151.

Sklower, K. et al. "The PPP Multilink Protocol (MP)" Network Working Group, Nov. 1994 (15 pages).

"Sunset xDSL: Prequalification of ADSL Circuits with ATU-C Emulation," Sunrise Telecom Inc., Application Series, 2001, San Jose, USA, p. 3, available at <http://www.sunrisetelecom.com/technotes/APP-xDSL-8B.pdf>.

"VDSL2 ITU-T Recommendation G.993.2," International Telecommunication Union, Feb. 2006, 252 pages.

Wolman, Alec et al. "Latency Analysis of TCP on an ATM Network" University of Washington, Printed Sep. 19, 2014 (14 pages).

Yamada, Hitoshi et al. "QoS Control by Traffic Engineering in Content Delivery Networks" Fujitsu Science and Technology Journal, Dec. 2003 (11 pages).

International Search Report for International (PCT) Patent Application No. PCT/US2005/036015, dated Feb. 8, 2006.

Written Opinion for International (PCT) Patent Application No. PCT/US2005/036015, dated Feb. 8, 2006.

International Preliminary Report on Patentability for International (PCT) Patent Application No. PCT/US2005/036015, dated Apr. 26, 2007.

Examiner's First Report for Australian Patent Application No. 2005296086, dated Jun. 24, 2009.

Examiner's First Report for Australian Patent Application No. 2011201250 dated May 13, 2013.

Notice of Acceptance for Australian Patent Application No. 2015200618 dated Jul. 15, 2015.

Examiner's Report for Canadian Patent Application No. 2,580,280, dated Sep. 14, 2012.

Notice of Allowance for Canadian Patent Application No. 2,580,280, dated Aug. 5, 2013.

Examiner's Report for Canadian Patent Application No. 2,869,452, dated Dec. 15, 2014.

Notice of Allowance for Canadian Patent Application No. 2,869,452, dated Apr. 20, 2015.

Examiner's Report for Canadian Patent Application No. 2,909,150, dated Aug. 10, 2016.

Notice of Allowance for Canadian Patent Application No. 2,909,150, dated Mar. 28, 2017.

Notification of the First Office Action (including translation) for Chinese Patent Application No. 200580032703, dated Sep. 25, 2009.

Official Action (including translation) for Chinese Patent Application No. 200580032703, dated May 18, 2011.

US 10,409,510 B2

Page 5

(56)

References Cited

OTHER PUBLICATIONS

Official Action (including translation) for Chinese Patent Application No. 200580032703.1, dated Mar. 28, 2012.

Decision of Refusal (including translation) for Chinese Patent Application No. 200580032703.1, dated Sep. 5, 2012.

Notification of Reexamination (including translation) for Chinese Patent Application No. 200580032703.1, dated Oct. 29, 2014.

Reexamination Decision (including translation) for Chinese Patent Application No. 200580032703.1, dated Apr. 14, 2015.

First Office Action (including translation) for Chinese Patent Application No. 201510413116.2, dated Sep. 30, 2017.

Official Action for European Application No. 05807443.6, dated Mar. 6, 2013.

Official Action for European Application No. 05807443.6, dated Dec. 8, 2015.

Intention to Grant for European Application No. 05807443.6, dated Sep. 22, 2017.

First Examination Report for Indian Patent Application No. 1208/KOLNP/2007, dated Mar. 18, 2013.

Official Action (translation only) for Korean Patent Application No. 10-2007-7008270, dated Jun. 30, 2011.

Notice of Allowance (including translation) for Korean Patent Application No. 10-2007-7008270, dated Mar. 29, 2012.

Official Action (translation only) for Korean Patent Application No. 10-2010-7022463, dated Jun. 30, 2011.

Notice of Allowance (including translation) for Korean Patent Application No. 10-2010-7022463, dated Mar. 29, 2012.

Official Action (including translation) for Japanese Patent Application No. 2007-535818, dated Jul. 11, 2011.

Notice of Allowance (Including Translation) for Japanese Patent Application No. 2007-535818, dated Dec. 12, 2011.

Official Action (including translation) for Japanese Patent Application No. 2008-264540, dated Jul. 11, 2011.

Official Action (including translation) for Japanese Patent Application No. 2008-264540, dated Dec. 12, 2011.

Notice of Allowance for Japanese Patent Application No. 2008-264540, dated Mar. 26, 2012.

Invitation to Pay Additional Fees (including partial international search report) for International (PCT) Patent Application No. PCT/US2007/066522, dated Feb. 6, 2008.

International Search Report for International (PCT) Patent Application No. PCT/US2007/066522, dated Apr. 14, 2008.

Written Opinion for International (PCT) Patent Application No. PCT/US2007/066522, dated Apr. 14, 2008.

International Preliminary Report on Patentability for International (PCT) Patent Application No. PCT/US2007/066522, dated Oct. 23, 2008.

Examiner's First Report on Australian Patent Application No. 2007257055, dated Mar. 30, 2010.

Examiner's Report for Canadian Patent Application No. 2,647,589, dated Dec. 16, 2013.

Examiner's Report for Canadian Patent Application No. 2,647,589, dated Feb. 26, 2015.

Examiner's Report for Canadian Patent Application No. 2,647,589, dated Feb. 25, 2016.

Examiner's Report for Canadian Patent Application No. 2,647,589, dated Feb. 10, 2017.

Notice of Allowance for Canadian Patent Application No. 2,647,589, dated Jan. 12, 2018.

Official Action (including translation) for Chinese Patent Application No. 200780012891.0, dated Mar. 16, 2011.

Notification of the Second Office Action (including translation) for Chinese Patent Application No. 200780012891.0, dated Mar. 7, 2012.

Notification of the Second Office Action (including translation) for Chinese Patent Application No. 200780012891.0, dated Dec. 12, 2012.

Official Action for Columbian Patent Application No. 08-109-377, dated Nov. 5, 2010.

Examination Report for European Patent Application No. 07811844.5, dated Apr. 1, 2009.

Official Action for European Patent Application No. 07811844.5, dated Jul. 9, 2010.

Official Action for European Patent Application No. 07811844.5, dated Dec. 21, 2010.

Official Action for European Patent Application No. 07811844.5, dated Dec. 18, 2012.

Communication Under Rule 71(3) EPC—Intention to Grant for European Application No. 07811844.5, dated May 9, 2016.

European Search Report and Opinion for European Patent Application No. 10000017.3, dated Mar. 17, 2010.

Official Action for European Patent Application No. 10000017.3, dated Nov. 3, 2010.

Official Action for European Patent Application No. 10000017.3, dated Nov. 20, 2013.

Official Action for European Patent Application No. 10000017.3, dated Oct. 20, 2015.

Intention to Grant for European Patent Application No. 10000017.3, dated Sep. 16, 2016.

European Search Report and Opinion for European Patent Application No. 10000016.5, dated Mar. 3, 2010.

Official Action for European Patent Application No. 10000016.5, dated Nov. 3, 2010.

Official Action for European Patent Application No. 10000016.5, dated Dec. 22, 2011.

Communication Under Rule 71(3) EPC—Intention to Grant for European Patent Application No. 10000016.5, dated Dec. 18, 2012.

Decision to Grant a European Patent Pursuant to Article 97(1) EPC for European Patent Application No. 10000016.5, dated May 31, 2013.

European Search Report for European Patent Application No. 17020026.5 dated Apr. 25, 2017.

European Search Report for European Patent Application No. 17020525.6 dated Feb. 22, 2018.

Official Action for Japanese Patent Application No. 2009-505623, dated Apr. 4, 2011.

Official Action (including translation) for Japanese Patent Application No. 2009-505623, dated Oct. 31, 2011.

Official Action for Japanese Patent Application No. 2010-017356, dated Apr. 18, 2011.

Official Action (including translation) for Japanese Patent Application No. 2010-017356, dated Aug. 29, 2011.

Decision of Final Rejection (Including Translation) for Japanese Patent Application No. 2010-017356, dated Apr. 23, 2012.

Official Action for Japanese Patent Application No. 2012-042978, dated Jun. 3, 2013.

Notice of Allowance for Japanese Patent Application No. 2012-042978, dated Feb. 17, 2014.

Official Action for Japanese Patent Application No. 2013-246257 dated Jan. 26, 2015.

Official Action (Including Translation) for Japanese Patent Application No. 2013-246257 dated Nov. 16, 2015.

Notice of Allowance (Including Translation) for Japanese Patent Application No. 2013-246257 dated May 30, 2016.

Official Action for Korean Patent Application No. 10-2008-7024792, dated Aug. 29, 2013.

Official Action (including translation) for Korean Patent Application No. 10-2008-7024792 dated Feb. 23, 2015.

Official Action (including translation) for Korean Patent Application No. 10-2008-7024792 dated Dec. 14, 2015.

Official Action (including translation) for Korean Patent Application No. 10-2008-7024792 dated Jul. 26, 2016.

Notice of Allowance (including translation) for Korean Patent Application No. 10-2008-7024792 dated Feb. 17, 2017.

Official Action (including translation) for Korean Patent Application No. 10-2014-7005299 dated Apr. 4, 2014.

Official Action (including translation) for Korean Patent Application No. 10-2014-7005299 dated Feb. 23, 2015.

Official Action (including translation) for Korean Patent Application No. 10-2014-7005299 dated Dec. 14, 2015.

Official Action (including translation) for Korean Patent Application No. 10-2017-7012757 dated Jun. 19, 2017.

US 10,409,510 B2

Page 6

(56)

References Cited

OTHER PUBLICATIONS

Official Action (including translation) for Korean Patent Application No. 10-2017-7036067 dated Jan. 26, 2018.

Official Action (including translation) for Mexican Patent Application No. MX/a/2008/012505, dated Apr. 22, 2010.

Official Action (including translation) for Mexican Patent Application No. MX/a/2008/012505, dated Aug. 9, 2011.

Official Notification of Intent to Grant (including translation) for Mexican Patent Application No. MX/a/2008/012505, dated Apr. 3, 2012.

Official Action (including translation) for Mexican Patent Application No. MX/a/2011/005751, dated Jun. 6, 2013.

Official Action for U.S. Appl. No. 11/246,163, dated Feb. 24, 2009.

Official Action for U.S. Appl. No. 11/246,163, dated Dec. 9, 2009.

Notice of Allowability for U.S. Appl. No. 11/246,163, dated Sep. 7, 2010.

Notice of Allowability for U.S. Appl. No. 12/761,586, dated Oct. 6, 2010.

Notice of Allowability for U.S. Appl. No. 12/853,020, dated Oct. 6, 2010.

Official Action for U.S. Appl. No. 12/901,699, dated Jan. 6, 2012.

Notice of Allowance for U.S. Appl. No. 12/901,699, dated Jul. 27, 2012.

Official Action for U.S. Appl. No. 13/567,261, dated Sep. 28, 2012.

Notice of Allowance for U.S. Appl. No. 13/567,261, dated May 21, 2013.

Official Action for U.S. Appl. No. 13/942,938, dated Sep. 25, 2013.

Notice of Allowance for U.S. Appl. No. 13/942,938, dated Oct. 8, 2013.

Official Action for U.S. Appl. No. 14/081,469 dated Dec. 17, 2014.

Notice of Allowance for U.S. Appl. No. 14/081,469, dated Apr. 3, 2015.

Official Action for U.S. Appl. No. 14/730,874 dated Jun. 30, 2015.

Notice of Allowance for U.S. Appl. No. 14/730,874 dated Jan. 7, 2016.

Office Action for U.S. Appl. No. 15/046,821 dated Mar. 24, 2016.

Notice of Allowance for U.S. Appl. No. 15/046,821 dated Sep. 23, 2016.

Office Action for U.S. Appl. No. 15/372,841 dated Apr. 21, 2017.

Notice of Allowance for U.S. Appl. No. 15/372,841 dated Dec. 20, 2017.

Official Action for U.S. Appl. No. 12/295,828, dated Jan. 5, 2012.

Notice of Allowance for U.S. Appl. No. 12/295,828, dated Aug. 17, 2012.

Notice of Allowance for U.S. Appl. No. 12/783,758, dated Dec. 26, 2012.

Official Action for U.S. Appl. No. 13/766,059, dated Oct. 2, 2013.

Notice of Allowance for U.S. Appl. No. 13/766,059, dated Nov. 25, 2013.

Official Action for U.S. Appl. No. 14/159,125, dated Feb. 6, 2015.

Official Action for U.S. Appl. No. 14/159,125, dated Jun. 16, 2015.

Official Action for U.S. Appl. No. 14/159,125, dated Dec. 31, 2015.

Notice of Allowance for U.S. Appl. No. 14/159,125, dated Aug. 1, 2016.

Office Action for U.S. Appl. No. 15/298,526, dated Feb. 27, 2017.

Office Action for U.S. Appl. No. 15/298,526, dated Dec. 1, 2017.

Official Action for U.S. Appl. No. 12/760,728, dated Apr. 27, 2012.

Official Action for U.S. Appl. No. 12/760,728, dated Jan. 2, 2013.

Official Action for U.S. Appl. No. 12/760,728, dated Jun. 20, 2013.

Official Action for U.S. Appl. No. 12/760,728, dated Oct. 2, 2013.

Notice of Allowance for U.S. Appl. No. 12/760,728, dated Oct. 21, 2013.

Official Action for U.S. Appl. No. 12/783,765, dated May 17, 2012.

Official Action for U.S. Appl. No. 12/783,765, dated Dec. 17, 2012.

Notice of Allowance for U.S. Appl. No. 12/783,765, dated May 9, 2013.

Official Action for U.S. Appl. No. 14/075,194, dated Jan. 28, 2015.

Notice of Allowance for U.S. Appl. No. 14/075,194, dated Apr. 8, 2015.

Official Action for U.S. Appl. No. 14/742,334, dated Mar. 24, 2017.

Notice of Allowance for U.S. Appl. No. 14/742,334, dated Jun. 5, 2017.

Official Action for U.S. Appl. No. 15/678,870, dated Dec. 13, 2017.

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Nov. 4, 2013-Oct. 19, 2015; (3,844 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Nov. 10, 2015-Jan. 5, 2016; (102 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Jan. 20, 2016-Feb. 2, 2016; (104 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Feb. 9, 2016-Mar. 2, 2016; (228 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Aug. 31, 2015 and Mar. 17, 2016-Apr. 22, 2016; (194 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Feb. 25, 2016, mailed publicly available on May 25, 2016 (40 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Apr. 27, 2016-May 24, 2016; (813 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Mar. 6, 2016—made publicly available June 1, 2016; (61 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Jun. 3, 2016-Jun. 6, 2016; (67 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Jun. 27, 2016; (2 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Aug. 2-Sep. 14, 2016; (58 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Sep. 26, 2016; (19 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Oct. 26, 2016-Nov. 17, 2016; (37 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Sep. 18, 2016 and made available on Dec. 19, 2016; (36 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed From Dec. 9, 2016-Feb. 3, 2017; (688 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed made available on Dec. 19, 2016; (36 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware

US 10,409,510 B2

Page 7

(56)

References Cited

OTHER PUBLICATIONS

(Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Feb. 6, 2017 to May 1, 2017; (124 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Feb. 10, 2017, made available on May 11, 2017; (52 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from May 2, 2017 to Jul. 14, 2017; (1183 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Jul. 24, 2017-Oct. 26, 2017; (3953 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed on Sep. 7, 2017 and made Publicly Available on December 6, 2017; (156 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Oct. 27, 2017-Dec. 21, 2017; (1,411 pages). Defendant 2WIRE, Inc.'s Preliminary Invalidity Contentions with Regard to Representative Asserted Claims for *TQ Delta, LLC v. 2WIRE, Inc.*—Including Claim Charts for Family 3 with Exhibits F-1 to F-9 and G-1 to G-25; In the United States District Court for the District of Delaware; Civil Action No. 13-01835-RGA; filed Sep. 24, 2015 (539 pages). Defendant 2WIRE, Inc.'s Invalidity Contentions in Response to *TQ Delta's* Dec. 8, 2016 Final Infringement Contentions Including Claim Charts for Family 3 with Exhibits F-1 to F-9 and G-1 to G-25; In the United States District Court for the District of Delaware; Civil Action No. 13-01835-RGA; filed Jan. 23, 2017 (537 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Nov. 4, 2013-Nov. 30, 2015; (1722 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Dec. 16, 2015-Jan. 6, 2016; (193 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Jan. 20, 2016-Feb. 8, 2016; (252 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Feb. 9, 2016-Mar. 2, 2016; (225 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Mar. 17, 2016-Apr. 22, 2016; (152 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed on Feb. 25, 2016, made publicly available May 25, 2016; (40 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of

Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Apr. 27, 2016-May 24, 2016; (813 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed on Mar. 3, 2016 made publicly available June 1, 2016; (61 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Jun. 3, 2016-Jun. 7, 2016; (138 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed on Jun. 27, 2016; (2 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Aug. 2-Aug. 23, 2016; (9 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed from Sep. 16, 2016; (2 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed on Sep. 26, 2016; (19 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Oct. 26, 2016-Nov. 17, 2016; (35 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Dec. 9, 2016-Feb. 3, 2017; (21 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Feb. 8, 2017 to Apr. 26, 2017; (118 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed on Feb. 10, 2017, made available on May 11, 2017; (52 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed May 2, 2017 to Jul. 14, 2017; (1080 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Jul. 24, 2017-Oct. 25, 2017; (3668 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Sep. 7, 2017, made Publicly Available on Dec. 6, 2017; (156 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhone Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Oct. 30, 2017-Dec. 5, 2017; (862 pages). Defendant Zhone Technologies, Inc.'s Invalidity Contentions with Regard to Representative Asserted Claims for *TQ Delta, LLC v. Zhone Technologies, Inc.*—Including Claim Charts for Family 3 with Exhibits 43-79; In the United States District Court for the District of Delaware; Civil Action No. 13-01836-RGA; filed Sep. 25, 2015 (961 pages). Defendant Zhone Technologies, Inc.'s Final Invalidity Contentions in Response to Plaintiffs Final Infringement Charts Regarding Non-Broadcom Products for *TQ Delta, LLC v. Zhone Technologies,*

US 10,409,510 B2

Page 8

(56)

References Cited

OTHER PUBLICATIONS

Inc.—Including Claim Charts for Family 3 with Exhibits 58-94; In the United States District Court for the District of Delaware; Civil Action No. 13-01836-RGA; filed Jan. 23, 2017 (945 pages).

Defendant Zhong Technologies, Inc.'s Invalidity Contentions with Respect to Representative Asserted Claims for *TQ Delta, LLC v. Zhong Technologies, Inc.*—Including Claim Charts for Family 9 with Exhibits 138-150; In the United States District Court for the District of Delaware; Civil Action No. 13-01836-RGA; filed Sep. 25, 2015 (246 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Dec. 9, 2013-Nov. 30, 2015; (1996 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Dec. 16, 2015-Dec. 16, 2015; (48 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Jan. 20, 2016-Feb. 8, 2016; (349 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Feb. 9, 2016-Mar. 2, 2016; (223 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Mar. 17, 2016-Apr. 22, 2016; (152 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed on Feb. 25, 2016, made publicly available May 25, 2016; (40 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Apr. 27, 2016-May 24, 2016; (809 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed on Mar. 3, 2016, made publicly June 1, 2016; (61 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Jun. 3, 2016-Jun. 13, 2016; (140 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Jun. 14, 2016; (2 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed on Jun. 27, 2016; (2 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Aug. 2, 2016-Sep. 1, 2016; (11 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the

District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed on Sep. 26, 2016; (19 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Oct. 26, 2016-Nov. 17, 2016; (35 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Dec. 9, 2016-Feb. 3, 2017; (23 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Feb. 8, 2017-May 1, 2017; (69 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed on Feb. 10, 2017, made available on May 11, 2017; (52 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from May 2, 2017-Jul. 14, 2017; (1080 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Jul. 24, 2017-Oct. 25, 2017; (3670 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Sep. 7, 2017, made Publicly Available on Dec. 6, 2017; (156 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Oct. 27, 2017-Dec. 21, 2017; (1,843 pages).

Defendant Zyxxel's Initial Invalidity Contentions with Respect to Representative Asserted Claims for *TQ Delta, LLC v. Zyxxel Communications, Inc. and Zyxxel Communications Corporation*—Including Claim Charts for Family 3 with Exhibits C1-C36; In the United States District Court for the District of Delaware; Civil Action No. 13-02013-RGA; filed Sep. 25, 2015 (729 pages).

Defendant Zyxxel's Technologies, Inc.'s Final Invalidity Contentions in Response to Plaintiffs Dec. 8, 2016 Final Infringement Charts Regarding Non-Broadcom Products for *TQ Delta, LLC v. Zyxxel Communications, Inc. and Zyxxel Communications Corporation*—Including Claim Charts for Family 3 with Exhibits C1-C30 and C32-C36; In the United States District Court for the District of Delaware; Civil Action No. 13-02013-RGA; filed Jan. 23, 2017 (754 pages).

Defendant Zyxxel's Initial Invalidity Contentions with Respect to Representative Asserted Claims for *TQ Delta, LLC v. Zyxxel Communications, Inc. and Zyxxel Communications Corporation*—Including Claim Charts for Family 9 with Exhibits J2-J13; In the United States District Court for the District of Delaware; Civil Action No. 13-2013-RGA; filed Sep. 25, 2015 (236 pages).

Defendant Zyxxel's Technologies, Inc.'s Final Invalidity Contentions in Response to Plaintiffs Dec. 8, 2016 Final Infringement Charts Regarding Non-Broadcom Products for *TQ Delta, LLC v. Zyxxel Communications, Inc. and Zyxxel Communications Corporation*—Including Claim Charts for Family 9 with Exhibits J8-J14; In the United States District Court for the District of Delaware; Civil Action No. 13-2013-RGA; filed Jan. 23, 2017 (225 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Jul. 17, 2014-Oct. 19, 2015—(2,489 pages).

US 10,409,510 B2

Page 9

(56)

References Cited

OTHER PUBLICATIONS

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Jan. 20, 2016-Feb. 8, 2016—(81 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Feb. 9, 2016-Mar. 1, 2016; (13 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Mar. 28, 2016-May 31, 2016—(8 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Mar. 8, 2016, made publicly available June 6, 2016—(60 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Jun. 7, 2016-Jun. 8, 2016; (73 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Jun. 15, 2016; (2 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed on Jun. 27, 2016; (2 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Aug. 2-Sep. 1, 2016; (11 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Nov. 4, 2016-Nov. 17, 2016; (11 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Dec. 9, 2016-Feb. 3, 2017; (19 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Feb. 8, 2017-May 1, 2017; (128 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed on Feb. 10, 2017, made available on May 11, 2017; (52 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from May 2, 2017-Jul. 14, 2017; (1087 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Jul. 21, 2017-Oct. 26, 2017; (4038 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Sep. 7, 2017, made Publicly Available on Dec. 6, 2017; (157 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Oct. 27, 2017-Dec. 21, 2017; (1664 pages).

Defendant Adtran, Inc.'s Preliminary Invalidity Contentions with Regard to Representative Asserted Claims for *TQ Delta, LLC v.*

Adtran, Inc.—Including Claim Charts for Family 3 as Exhibits 3-1-3-28; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA and Civil Action No. 1:15-cv-00121-RGA; filed Feb. 9, 2016 (643 pages).

Defendant Adtran, Inc.'s Preliminary Invalidity Contentions with Regard to Representative Asserted Claims for *TQ Delta, LLC v. Adtran, Inc.*—Including Claim Charts for Family 9 as Exhibits 9-1-9-23; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA and Civil Action No. 1:15-cv-00121-RGA; filed Feb. 9, 2016 (406 pages).

Defendant Adtran, Inc.'s Invalidity Contentions in Response to TQ Delta's Dec. 8, 2016 Final Infringement Contentions for *TQ Delta, LLC v. Adtran, Inc.*—Including Claim Charts for Family 9 as Exhibits 9-1-9-23; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA and Civil Action No. 1:15-cv-00121-RGA; filed Jan. 23, 2017 (347 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Jul. 17, 2014-Mar. 1, 2016; (1,444) pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Mar. 28, 2016-May 31, 2016; (8 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents on Mar. 8, 2016 made publicly available Jun. 6, 2016; (60 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Jun. 7, 2016-Jun. 8, 2016; (73 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Jun. 15, 2016; (2 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed on Jun. 27, 2016; (2 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Aug. 2-Sep. 1, 2016; (11 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Nov. 4, 2016-Nov. 17, 2016; (11 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Dec. 9, 2016-Feb. 3, 2017; (19 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Feb. 8, 2017-May 1, 2017; (118 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed on Feb. 10, 2017, made available on May 11, 2017; (52 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from May 2, 2017-Jul. 14, 2017; (1083 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Jul. 21, 2017-Oct. 26, 2017; (4150 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware

US 10,409,510 B2

Page 10

(56)

References Cited

OTHER PUBLICATIONS

(Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Sep. 7, 2017, made Publicly Available on Dec. 6, 2017; (157 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Oct. 27, 2017-Dec. 21, 2017; (1662 pages).

Documents filed with District Court Proceedings for *Adtran Inc. vs. TQ Delta, LLC*; U.S. District Court, for the Northern District of Alabama (Northeastern); Civil Action No. 5:14-cv-01381-JEO; Includes documents filed from Jul. 17, 2014-Jan. 27, 2015—(568 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Feb. 11, 2019-May 9, 2019; (12,491 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Feb. 13, 2019-May 8, 2019; (21 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Feb. 22, 2019-May 9, 2019; (36 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Feb. 22, 2019-May 9, 2019; (35 pages).

Office Action for U.S. Appl. No. 16/046,494, dated Oct. 18, 2018. Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents made publicly available on Oct. 25, 2018; (94 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Sep. 11, 2018-Nov. 21, 2018; (317 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made publicly available on Oct. 25, 2018; (94 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc., et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Sep. 18, 2018-Nov. 27, 2018; (302 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents made publicly available on Oct. 25, 2018; (94 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Sep. 18, 2018-Nov. 21, 2018; (486 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents made publicly available on Oct. 25, 2018; (94 pages).

Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Sep. 18, 2018-Nov. 21, 2018; (486 pages).

Office Action for European Patent Application No. 17020525.6 dated Nov. 12, 2018.

Notice of Allowance (including translation) for Korean Patent Application No. 10-2017-7036067 dated Nov. 26, 2018.

Notice of Allowance for U.S. Appl. No. 15/298,526, dated Jun. 4, 2018.

Official Action for U.S. Appl. No. 15/678,870, dated Apr. 12, 2018. Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents made Publicly Available on Mar. 26, 2018; (120 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents made Publicly Available on Apr. 16, 2018; (145 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents made Publicly Available on May 9, 2018; (52 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Mar. 27, 2018-Jun. 11, 2018; (450 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhong Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents made Publicly Available on Mar. 26, 2018; (120 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made Publicly available on Mar. 26, 2018; (120 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made Publicly available on Apr. 16, 2018; (145 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made Publicly available on Apr. 17, 2018; (42 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made Publicly available on May 10, 2018; (52 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made Publicly available on May 14, 2018; (101 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Mar. 29, 2018-Jun. 8, 2018; (465 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents made publicly available on Mar. 26, 2018; (120 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents made Publicly available on Apr. 16, 2018; (145 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents made Publicly available on May 10, 2018; (52 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents made Publicly available on May 14, 2018; (101 pages).

Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware

US 10,409,510 B2

Page 11

(56)

References Cited

OTHER PUBLICATIONS

(Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Mar. 29, 2018-Jun. 7, 2018; (956 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents made Publicly available on Mar. 26, 2018; (120 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents made Publicly available on Apr. 16, 2018; (145 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents made Publicly available on May 10, 2018; (52 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents made Publicly available on May 14, 2018; (101 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Mar. 29, 2018-Jun. 7, 2018; (956 pages). Examiner's Report for Canadian Patent Application No. 2,980,607 dated Aug. 10, 2018. Second Office Action (including translation) for Chinese Patent Application No. 201510413116.2, dated Aug. 1, 2018. U.S. Appl. No. 16/261,109, filed Jan. 29, 2019, Tzannes et al. Official Action for U.S. Appl. No. 15/678,870, dated Jan. 25, 2019. Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Dec. 10, 2018-Feb. 9, 2019; (5,536 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Dec. 3, 2018-Feb. 6, 2019; (35 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Dec. 3, 2018-Feb. 6, 2019; (543 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Dec. 3, 2018-Feb. 6, 2019; (543 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Feb. 1, 2018-Mar. 19, 2018; (1,482 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zhong Technologies Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01836-RGA; Includes documents filed Feb. 1, 2018-Mar. 6, 2018; (326 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Feb. 1, 2018-Mar. 19, 2018; (4,366 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Feb. 1, 2018-Mar. 19, 2018; (4,228 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Feb. 1, 2018-Mar. 19, 2018; (4,228 pages). Corrected Notice of Allowance for U.S. Appl. No. 15/298,526, dated Jun. 29, 2018.

Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents made publicly available on Jul. 12, 2018; (63 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from Jun. 11, 2018-Sep. 10, 2018; (133 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents made publicly available on Jul. 12, 2018; (118 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from Jun. 11, 2018-Sep. 10, 2018; (272 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents made publicly available on Jul. 12, 2018; (181 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from Jul. 3, 2018-Sep. 10, 2018; (696 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents made publicly on Jul. 12, 2018; (181 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from Jun. 11, 2018-Sep. 10, 2018; (693 pages). Office Action for Brazilian Patent Application No. PI0709871-5, dated Apr. 26, 2019. Examiner's Report for Canadian Patent Application No. 3,011,163, dated Apr. 16, 2019. Office Action for European Patent Application No. 17020525.6 dated Apr. 5, 2019. Official Action (including translation) for Korean Patent Application No. 10-2019-7005116 dated Apr. 16, 2019. U.S. Appl. No. 16/046,494, filed Jul. 26, 2018, Tzannes. Third Office Action (including translation) for Chinese Patent Application No. 201510413116.2, dated Mar. 22, 2019. Notice of Allowance for U.S. Appl. No. 16/046,494, dated Jun. 13, 2019. Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents made publicly available on Jun. 13, 2019; (19 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. 2WIRE, Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-01835-RGA; Includes documents filed from May 9, 2019 - Jul. 15, 2019; (1076 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Zyxel Communications Inc. et al.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:13-cv-02013-RGA; Includes documents filed from May 16, 2019 - Jul. 3, 2019; (11 pages). Documents filed with District Court Proceedings for *TQ Delta, LLC v. Adtran Inc.*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:14-cv-00954-RGA; Includes documents filed from May 10, 2019-Jul. 16, 2019; (1435 pages). Documents filed with District Court Proceedings for *Adtran Inc. v. TQ Delta, LLC*; U.S. District Court, for the District of Delaware (Wilmington); Civil Action No. 1:15-cv-00121-RGA; Includes documents filed from May 10, 2019-Jul. 16, 2019; (1433 pages).

* cited by examiner

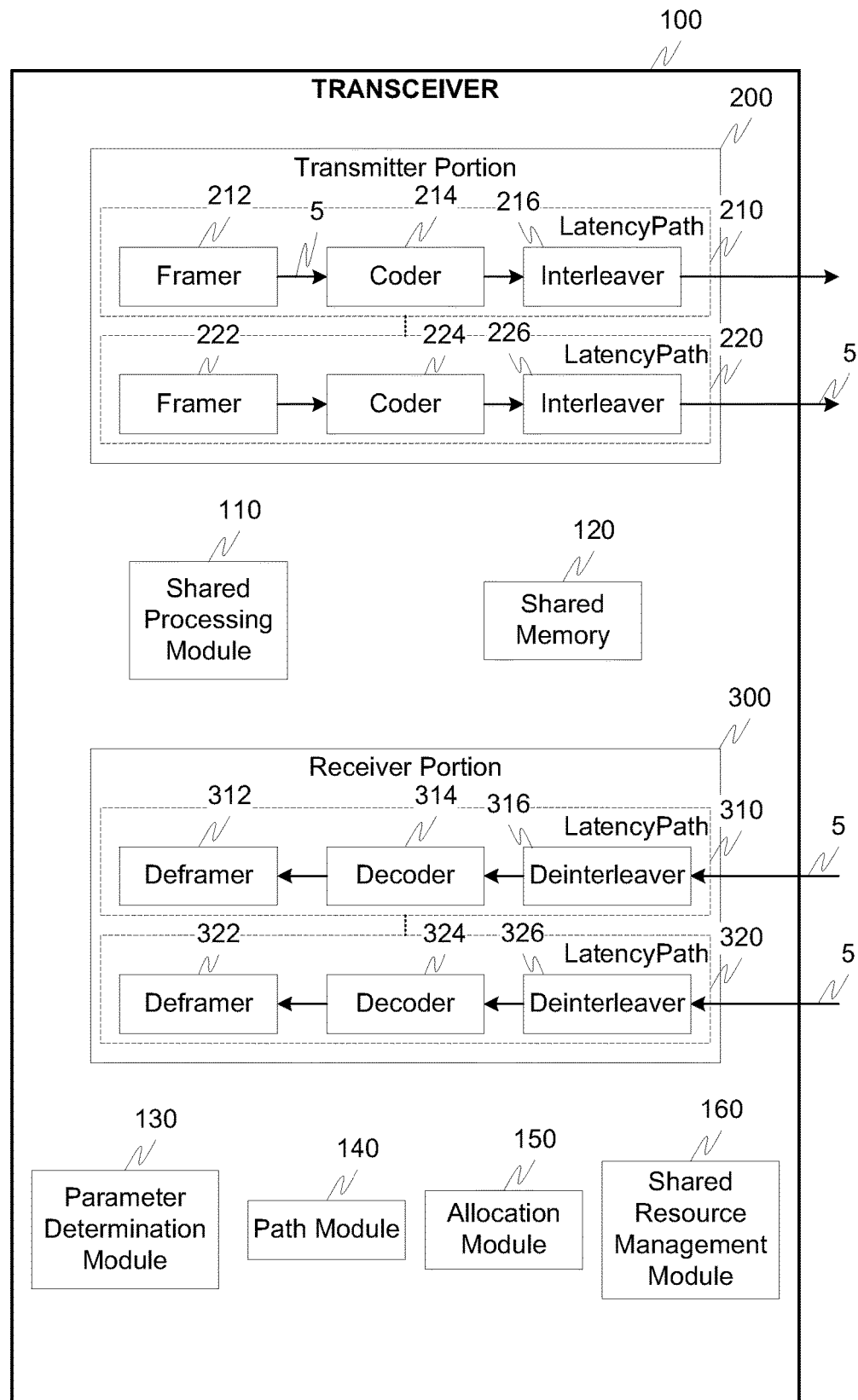


Fig. 1

U.S. Patent

Sep. 10, 2019

Sheet 2 of 3

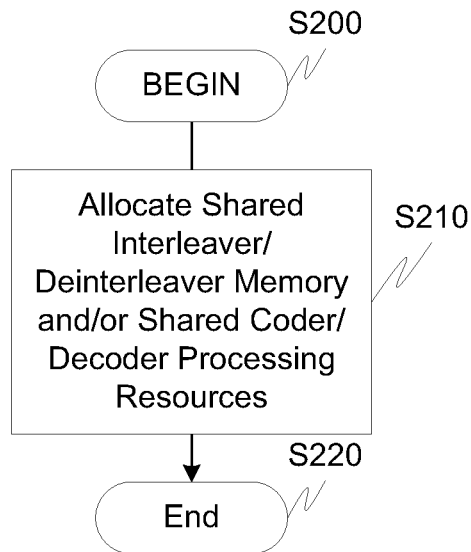
US 10,409,510 B2

Fig. 2

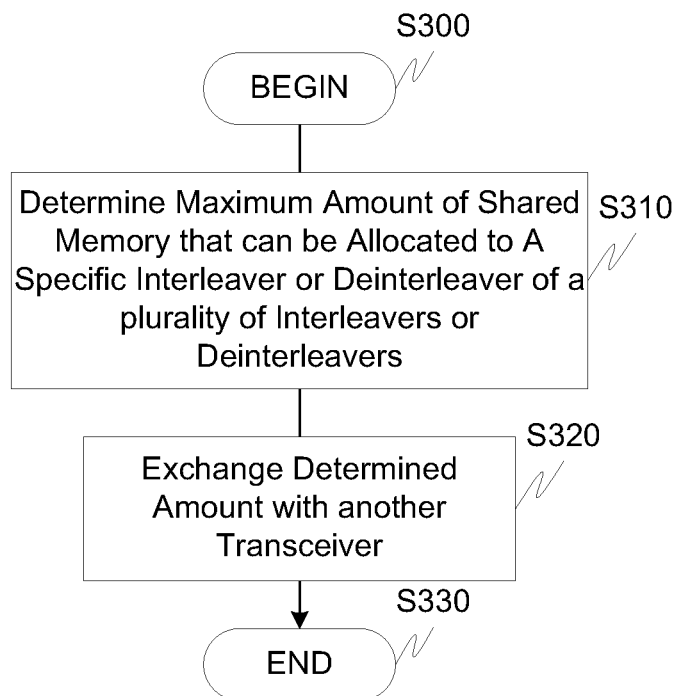


Fig. 3

U.S. Patent

Sep. 10, 2019

Sheet 3 of 3

US 10,409,510 B2

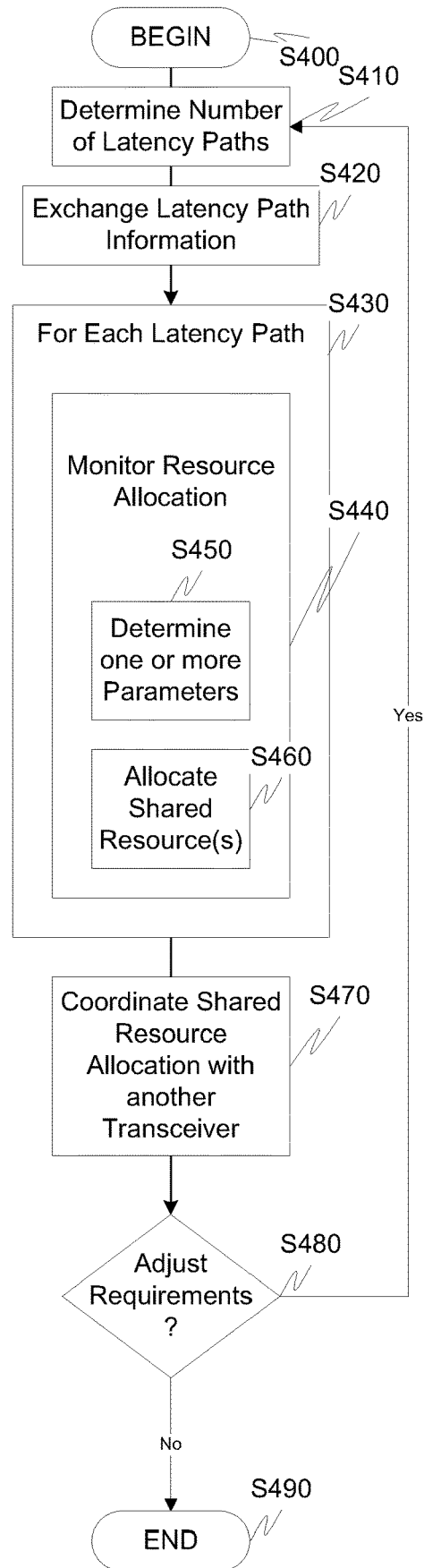


Fig. 4

US 10,409,510 B2

1

**RESOURCE SHARING IN A
TELECOMMUNICATIONS ENVIRONMENT****RELATED APPLICATION DATA**

This application is a Continuation of U.S. application Ser. No. 15/372,841, filed Dec. 8, 2016, now U.S. Pat. No. 9,898,220, which is a Continuation of U.S. application Ser. No. 15/046,821, filed Feb. 18, 2016, now U.S. Pat. No. 9,547,608, which is a Continuation of U.S. application Ser. No. 14/730,874, filed Jun. 4, 2015, now U.S. Pat. No. 9,286,251, which is a Continuation of U.S. application Ser. No. 14/081,469, filed Nov. 15, 2013, now U.S. Pat. No. 9,069,718, which is a Continuation of U.S. application Ser. No. 13/942,938, filed Jul. 16, 2013, now U.S. Pat. No. 8,607,126, which is a Continuation of U.S. application Ser. No. 13/567,261, filed Aug. 6, 2012, now U.S. Pat. No. 8,495,473, which is a Continuation of U.S. application Ser. No. 12/901,699, filed Oct. 11, 2010, now U.S. Pat. No. 8,276,048, which is a Continuation of Ser. No. 12/761,586, filed Apr. 16, 2010, now U.S. Pat. No. 7,844,882, which is a Continuation of U.S. application Ser. No. 11/246,163 filed Oct. 11, 2005, now U.S. Pat. No. 7,831,890, which claims the benefit of and priority under 35 U.S.C. § 119(e) to U.S. Patent Application No. 60/618,269, filed Oct. 12, 2004, entitled "Sharing Memory and Processing Resources in DSL Systems," each of which are incorporated herein by reference in their entirety.

BACKGROUND**Field of the Invention**

This invention generally relates to communication systems. More specifically, an exemplary embodiment of this invention relates to memory sharing in communication systems. Another exemplary embodiment relates to processing or coding resource sharing in a communication system.

Description of Related Art

U.S. Pat. Nos. 6,775,320 and 6,778,596 describe DSL systems supporting multiple applications and multiple framer/coder/interleaver FCI blocks (an FCI block is also referred to as a latency path). DSL systems carry applications that have different transmission requirements with regard to, for example, data rate, latency (delay), bit error rate (BER), and the like. For example, video typically requires a low BER ($<1E-10$) but can tolerate higher latency (>20 ms). Voice, on the other hand, typically requires a low latency (<1 ms) but can tolerate BER ($>1E-3$).

As described in U.S. Pat. No. 6,775,320, different applications can use different latency paths in order to satisfy the different application requirements of the communication system. As a result a transceiver must support multiple latency paths in order to support applications such as video, Internet access and voice telephony. When implemented in a transceiver, each of the latency paths will have a framer, coder, and interleaver block with different capabilities that depend on the application requirements.

SUMMARY

One difficulty with implementing multiple latency paths in a transceiver is the fact that a latency path is a complicated digital circuit that requires a large amount of memory and processing power. An interleaver within a latency path can

2

consume a large amount of memory in order to provide error correcting capability. For example, a typical DSL transceiver will have at least one latency path with approximately 16 kbytes of memory for the interleaver. Likewise, the coding block, for example, a Reed Solomon coder, consumes a large amount of processing power. In general, as the number of latency paths increase, the memory and processing power requirements for a communication system become larger.

Accordingly, an exemplary aspect of this invention relates to sharing memory between one or more interleavers and/or deinterleavers in a transceiver. More particularly, an exemplary aspect of this invention relates to shared latency path memory in a transceiver.

Additional aspects of this invention relate to configuring and initializing shared memory in a communication system. More particularly, an exemplary aspect of this invention relates to configuring and initializing interleaver/deinterleaver memory in a communication system.

Additional aspects of the invention relate to determining the amount of memory that can be allocated to a particular component by a communication system. More specifically, an exemplary aspect of the invention relates to determining the maximum amount of shared memory that can be allocated to one or more interleaves or deinterleavers.

According to another exemplary aspect of the invention, processing power is shared between a number of transceiver modules. More specifically, and in accordance with an exemplary embodiment of the invention, a coding module is shared between one or more coders and/or decoders.

Another exemplary embodiment of the invention relates to transitioning from a fixed memory configuration to a shared memory configuration during one or more of initialization and SHOWTIME (user data transmission).

An additional exemplary aspect of the invention relates to dynamically updating one or more of shared memory and processing resources based on changing communication conditions.

An additional exemplary aspect of the invention relates to updating one or more of shared memory and processing resources based on an updated communication parameter.

An additional exemplary aspect of the invention relates to updating the allocation of one or more of shared memory and processing resources based on an updated communication parameter(s).

Additional aspects of the invention relate to exchanging shared resource allocations between transceivers.

Additional exemplary aspects relate to a method of allocating shared memory in a transceiver comprising allocating the shared memory to a plurality of modules, wherein each of the plurality of modules comprise at least one interleaver, at least one deinterleaver or a combination thereof.

Still further aspects relate to the above method wherein the plurality of modules comprise interleavers.

Still further aspects relate to the above method wherein the plurality of modules comprise deinterleavers.

Still further aspects relate to the above method wherein the plurality of modules comprise at least one interleaver and at least one deinterleaver.

Additional exemplary aspects relate to a transceiver comprising a plurality of modules each including at least one interleaver, at least one deinterleaver or a combination thereof and a shared memory designed to be allocated to a plurality of the modules.

Still further aspects relate to the above transceiver wherein the plurality of modules comprise interleavers.

US 10,409,510 B2

3

Still further aspects relate to the above transceiver wherein the plurality of modules comprise deinterleavers.

Still further aspects relate to the above transceiver wherein the plurality of modules comprise at least one interleaver and at least one deinterleaver.

These and other features and advantages of this invention are described in, or are apparent from, the following description of the embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments of the invention will be described in detail, with reference to the following figures, wherein:

FIG. 1 is a functional block diagram illustrating an exemplary transceiver according to this invention;

FIG. 2 is a flowchart outlining an exemplary method of sharing resources according to this invention;

FIG. 3 is a flowchart outlining an exemplary method of determining a maximum amount of shared memory according to this invention; and

FIG. 4 is a flowchart outlining an exemplary resource sharing methodology according to this invention.

DETAILED DESCRIPTION

The exemplary embodiments of this invention will be described in relation to sharing resources in a wired and/or wireless communications environment. However, it should be appreciated, that in general, the systems and methods of this invention will work equally well for any type of communication system in any environment.

The exemplary systems and methods of this invention will also be described in relation to multicarrier modems, such as DSL modems and VDSL modems, and associated communication hardware, software and communication channels. However, to avoid unnecessarily obscuring the present invention, the following description omits well-known structures and devices that may be shown in block diagram form or otherwise summarized.

For purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the present invention. It should be appreciated however that the present invention may be practiced in a variety of ways beyond the specific details set forth herein.

Furthermore, while the exemplary embodiments illustrated herein show the various components of the system collocated, it is to be appreciated that the various components of the system can be located at distant portions of a distributed network, such as a telecommunications network and/or the Internet, or within a dedicated secure, unsecured and/or encrypted system. Thus, it should be appreciated that the components of the system can be combined into one or more devices, such as a modem, or collocated on a particular node of a distributed network, such as a telecommunications network. As will be appreciated from the following description, and for reasons of computational efficiency, the components of the system can be arranged at any location within a distributed network without affecting the operation of the system. For example, the various components can be located in a Central Office modem (CO, ATU-C, VTU-O), a Customer Premises modem (CPE, ATU-R, VTU-R), a DSL management device, or some combination thereof. Similarly, one or more functional portions of the system could be distributed between a modem and an associated computing device.

Furthermore, it should be appreciated that the various links, including communications channel 5, connecting the

4

elements can be wired or wireless links, or any combination thereof, or any other known or later developed element(s) that is capable of supplying and/or communicating data to and from the connected elements. The term module as used herein can refer to any known or later developed hardware, software, firmware, or combination thereof that is capable of performing the functionality associated with that element. The terms determine, calculate and compute, and variations thereof, as used herein are used interchangeably and include any type of methodology, process, mathematical operation or technique. FCI block and latency path are used interchangeably herein as well as transmitting modem and transmitting transceiver. Receiving modem and receiving transceiver are also used interchangeably.

FIG. 1 illustrates an exemplary embodiment of a transceiver 100 that utilizes shared resources. It should be appreciated that numerous functional components of the transceiver have been omitted for clarity. However, the transceiver 100 can also include the standard components found in typical communications device(s) in which the technology of the subject invention is implemented into.

According to an exemplary embodiment of the invention, memory and processing power can be shared among a plurality of transmitter and/or receiver latency paths, in a communications transceiver that carries or supports multiple applications. For example, the transmitter and/or receiver latency paths of the transceiver can share an interleaver/deinterleaver memory and the shared memory can be allocated to the interleaver and/or deinterleaver of each latency path. This allocation can be done based on the data rate, latency, BER, impulse noise protection requirements of the application, data or information being transported over each latency path, or in general any parameter associated with the communications system.

Likewise, for example, the transmitter and/or receiver latency paths can share a Reed-Solomon coder/decoder processing module and the processing power of this module can be allocated to each encoder and/or decoder. This allocation can be done based on the data rate/latency, BER, impulse noise protection requirements of the application data or information being transported over each latency path, or in general based on any parameter associated with the communication system.

In accordance with an exemplary operational embodiment, a first transceiver and a second transceiver transmit to one another messages during, for example, initialization which contain information on the total and/or shared memory capabilities of each transceiver and optionally information about the one or more latency paths. This information can be transmitted prior to determining how to configure the latency paths to support the application requirements. Based on this information, one of the modems can select an FCI configuration parameter(s) that meets the transmission requirements of each application being transported over each latency paths. While an exemplary of the embodiment of the invention will be described in relation to the operation of the invention and characteristics thereof being established during initialization, it should be appreciated that the sharing of resources can be modified and messages transmitted between a two transceivers at any time during initialization and/or user data transmission, i.e., SHOWTIME.

FIG. 1 illustrates an exemplary embodiment of a transceiver 100. The transceiver 100 includes a transmitter portion 200 and a receiver portion 300. The transmitter portion 200 includes one or more latency paths 210, 220, Similarly, the receiver portion 300 includes one or more

US 10,409,510 B2

5

latency paths **310, 320, . . .** Each of the latency paths in the transmitter portion **200** includes a framer, coder, and interleaver designated as **212, 214, 216** and **222, 224** and **226**, respectively. Each of the latency paths in the receiver portion includes a deframer, decoder, and deinterleaver designated as **312, 314, 316** and **322, 324, and 326**, respectively. The transceiver **100** further includes a shared processing module **110**, a shared memory **120**, a parameter determination module **130**, a path module **140**, an allocation module **150**, and a shared resource management module **160**, all interconnected by one or more links (not shown).

In this exemplary embodiment, the transceiver **100** is illustrated with four total transmitter portion and receiver portion latency paths, i.e., **210, 220, 310, and 320**. The shared memory **120** is shared amongst the two transmitter portion interleavers **216** and **226** and two receiver portion deinterleavers **316** and **326**. The shared processing module **110**, such as a shared coding module, is shared between the two transmitter portion coders **214** and **224** and the two receiver portion decoders **314** and **324**.

While the exemplary embodiment of the invention will be described in relation to a transceiver having a number of transmitter portion latency paths and receiver portion latency paths, it should be appreciated that this invention can be applied to any transceiver having any number of latency paths. Moreover, it should be appreciated that the sharing of resources can be allocated such that one or more of the transmitter portion latency paths are sharing a shared resource, one or more of the receiver portion latency paths are sharing a shared resource, or a portion of the transmitter portion latency paths and a portion of the receiver portion latency paths are sharing shared resources. Moreover, any one or more of the latency paths, or portions thereof, could also be assigned to a fixed resource while, for example, another portion of the latency path(s) assigned to a shared resource. For example, in latency path **210**, the interleaver **216** could be allocated a portion of the shared memory **120**, while the coder **214** could be allocated to a dedicated processing module, vice versa, or the like.

In accordance with the exemplary embodiment, a plurality of transmitter portion or receiver portion latency paths share an interleaver/deinterleaver memory, such as shared memory **120**, and a coding module, such as shared processing module **110**. For example, the interleaver/deinterleaver memory can be allocated to different interleavers and/or deinterleavers. This allocation can be based on parameters associated with the communication systems such as data rate, latency, BER, impulse noise protection, and the like, of the applications being transported. Similarly, a coding module, which can be a portion of the shared processing module **110**, can be shared between any one or more of the latency paths. This sharing can be based on requirements such as data rate, latency, BER, impulse noise protection, and the like, of the applications being transported.

For example, an exemplary transceiver could comprise a shared interleaver/deinterleaver memory and could be designed to allocate a first portion of the shared memory **120** to an interleaver, such as interleaver **216** in the transmitter portion of the transceiver and allocate a second portion of the shared memory **120** to a deinterleaver, such as **316**, in the receiver portion of the transceiver.

Alternatively, for example, an exemplary transceiver can comprise a shared interleaver/deinterleaver memory, such as shared memory **120**, and be designed to allocate a first portion of shared memory **120** to a first interleaver, e.g., **216**, in the transmitter portion of the transceiver and allocate a

6

second portion of the shared memory to a second interleaver, e.g., **226**, in the transmitter portion of the transceiver.

Alternatively, for example, an exemplary transceiver can comprise a shared interleaver/deinterleaver memory and be designed to allocate a first portion of the shared memory **120** to a first deinterleaver, e.g., **316**, in the receiver portion of the transceiver and allocate a second portion of the shared memory to a second deinterleaver, e.g., **326**, in the receiver portion of the transceiver. Regardless of the configuration, in general any interleaver or deinterleaver, or grouping thereof, be it in a transmitter portion or receiver portion of the transceiver, can be associated with a portion of the shared memory **120**.

Establishment, configuration and usage of shared resources is performed in the following exemplary manner. First, and in cooperation with the path module **140**, the number of transmitter and receiver latency paths (N) is determined. The parameter determination module **130** then analyses one or more parameters such as data rate, transmitter data rate, receiver data rate, impulse noise protection, bit error rate, latency, or the like. Based on one or more of these parameters, the allocation module **150** allocates a portion of the shared memory **120** to one or more of the interleaver and/or deinterleavers, or groupings thereof. This process continues until the memory allocation has been determined and assigned to each of the N latency paths.

Having determined the memory allocation for each of the latency paths, and in conjunction with the shared resource management **160**, the transceiver **100** transmits to a second transceiver one or more of the number of latency paths (N), the maximum interleaver memory for any one or more of the latency paths and/or the maximum total and/or shared memory for all of the latency paths.

Three examples of sharing interleaver/deinterleaver memory and coding processing in a transceiver are described below. The latency paths in these examples can be in the transmitter portion of the transceiver or the receiver portion of the transceiver.

Example #1

A first transmitter portion or receiver portion latency path may carry data from a video application, which needs a very low BER but can tolerate higher latency. In this case, the video will be transported using an latency path that has a large amount of interleaving/deinterleaving and coding (also known as Forward Error Correction (FEC) coding). For example, the latency path may be configured with Reed-Solomon coding using a codeword size of 255 bytes (N=255) with 16 checkbytes (R=16) and interleaving/deinterleaving using an interleaver depth of 64 (D=64). This latency path will require $N \cdot D = 255 \cdot 64 = 16$ Kbytes of interleaver memory at the transmitter (or deinterleaver memory at the receiver). This latency path will be able to correct a burst of errors that is less than 512 bytes in duration.

A second transmitter portion or receiver portion latency path may carry an internet access application that requires a medium BER and a medium amount of latency. In this case, the internet access application will be transported using a latency path that has a medium amount of interleaving and coding. For example, the latency path may be configured with Reed-Solomon coding using a codeword size of 128 bytes (N=128) with 8 checkbytes (R=8) and interleaving using an interleaver depth of 16 (D=32). This latency path will require $N \cdot D = 128 \cdot 32 = 4$ Kbytes of interleaver memory

US 10,409,510 B2

7

and the same amount of deinterleaver memory. This latency path will be able to correct a burst of errors that is less than 128 bytes in duration.

A third transmitter portion or receiver portion latency path may carry a voice telephony application, which needs a very low latency but can tolerate BER. In this case, the video will be transported using an latency path that has a large amount of interleaving and coding. For example, the third transmitter portion or receiver portion latency path may be configured with no interleaving or coding which will result in the lowest possible latency through the latency path but will provide no error correction capability.

According to the principles of this invention, a system carrying the three applications described above in Example #1, would have three latency paths that share one memory space containing at least $(16+4)=20$ Kbytes. The three latency paths also share a common coding block that is able to simultaneously encode (in the transmitter portion) or decode (in a receiver portion) two codewords with $N=255/R=16$ and $N=128/R=8$.

According to an exemplary embodiment of this invention, the latency paths can be reconfigured at initialization or during data transmission mode (also known as SHOWTIME in ADSL and VDSL transceivers). This would occur if, for example, the applications or application requirements were to change.

Example #2

If instead of 1 video application, 1 internet application and 1 voice application, there were 3 internet access applications then the transmitter portion and/or receiver portion latency paths would be reconfigured to utilize the shared memory and coding module in a different way. For example, the system could be reconfigured to have 3 transmitter portion or receiver portion latency paths, with each latency path being configured with Reed-Solomon coding using a codeword size of 128 bytes ($N=128$) with 8 checkbytes ($R=8$) and interleaving using an interleaver depth of 16 ($D=32$). Each latency path will require $N*D=128*32=4$ Kbytes of interleaver memory and each block will be able to correct a burst of errors that is less than 128 bytes in duration. Based on the example of carrying the three internet access applications described, the three latency path share one memory space containing at least $3*4=12$ Kbytes. Also the three latency paths share a common coding block that is able to simultaneously encode (on the transmitter side) or decode (on the receiver side) three codewords with $N=128/R=16$, $N=128/R=8$ and $N=128/R=8$.

Example #3

The system could be configured to carry yet another set of applications. For example, the latency paths could be configured to carry 2 video applications. In this case only 2 transmitter portion or receiver portion latency paths are needed, which means that the third latency path could be simply disabled. Also, assuming that the memory is constrained based on the first example above, then the maximum shared memory for these 2 latency paths is 20 kbytes. In this case, the system could be reconfigured to have 2 latency paths, with each block being configured with Reed-Solomon coding using a codeword size of 200 bytes ($N=200$) with 10 checkbytes ($R=10$) and interleaving/deinterleaving using an interleaver depth of 50 ($D=50$). Each latency path will require $N*D=200*50=10$ Kbytes of interleaver memory and each block will be able to correct a burst

8

of errors that is less than 250 bytes in duration. This configuration results in 20K of shared memory for both latency paths, which is the same as in the first example. In order to stay within the memory constraints of the latency paths, the error correction capability for each latency path is decreased to 250 bytes from 512 bytes in Example #1.

Another aspect of this invention is the how FCI configuration information is transmitted between a first modem and a second modem. FCI configuration information will depend on the requirements of the applications being transported over the DSL connection. This information may need to be forwarded during initialization in order to initially configure the DSL connection. This information may also need to be forwarded during SHOWTIME in order to reconfigure the DSL connection based on a change in applications or the application requirements.

According to one embodiment, a first modem determines the specific FCI configuration parameters, e.g., N, D, R as defined above, needed to meet specific application requirements, such as latency, burst error correction capability, etc. In order to determine the FCI configuration parameters, the first modem must know what are the capabilities of a second modem. For example, the first modem must know how many latency paths (FCI blocks) the second modem can support. Also the first modem must know the maximum amount of interleaver memory for each transmitter latency path. In addition, since the transmitter latency paths may share a common memory space the first modem must know the total shared memory for all transmitter latency paths. This way the first modem will be able to choose a configuration that can meet application requirements and also meet the transmitter portion latency path capabilities of the second modem.

For example, using values from examples above, a first transceiver could send a message to a second transceiver during initialization or during SHOWTIME containing the following information:

Number of supported transmitter and receiver latency paths=3

Max Interleaver Memory for latency path #1=16 Kbytes

Max Interleaver Memory for latency path #2=16 Kbytes

Max Interleaver Memory for latency path #3=16 Kbytes

Maximum total/shared memory for all latency paths=20 kBytes

Based on this information, and the application requirements, the first transceiver would select latency path settings. For example, if the applications are 1 video, 1 internet access and 1 voice application, the first transceiver could CONFIG. 3 latency paths as follows:

latency path #1—Video: $N=255$, $R=16$, $D=64$

latency path #2—Video: $N=128$, $R=8$, $D=32$

latency path #3—Video: $N=0$, $R=0$, $D=1$ (no coding or interleaving)

This would result in a total interleaver memory of 20 kbytes.

Alternatively, if for example, there are only 2 video applications, the first transceiver could configure 2 latency paths as follows:

latency path #1—Video: $N=200$, $R=10$, $D=50$

latency path #2—Video: $N=200$, $R=10$, $D=50$

latency path #3—Video: $N=0$, $R=0$, $D=1$ (no coding or interleaving)

This would also result in a total interleaver memory of 20 kbytes.

Alternatively, the second transceiver can determine the specific FCI configuration parameters, e.g., N, D, R as defined above, needed to meet specific application require-

US 10,409,510 B2

9

ments, such as latency, burst error correction capability, etc. As described above for the first transceiver, in order to determine the FCI configuration parameters, the second transceiver must first know what are the capabilities of the first transceiver. In this case, the first transceiver would send a message to the second transceiver containing the information described above and based on this information and the application requirements the second transceiver would select latency path settings.

FIG. 2 outlines an exemplary method of allocating shared memory in a transceiver. More specifically, control begins in step S200 and continues to step S210. In step S210, one or more of shared interleaver/deinterleaver memory and/or shared coder/decoder processing resources are allocated to one or more latency paths, in a transceiver. Control then continues to step S220 where the control sequence ends.

FIG. 3 outlines an exemplary method of exchanging shared resource allocations according to an exemplary embodiment of this invention. In particular, control begins in step S310. In step S310, a maximum amount of shared memory that can be allocated to a specific interleaver or deinterleaver of a plurality of interleavers or deinterleavers in a transceiver is determined. Next, in step S320, the determined maximum amount for one or more of the deinterleavers and/or interleavers is transmitted to another transceiver. Messages containing additional information can also be transmitted to the other transceiver and/or received from the other transceiver. Control then continues to step S330 where the control sequence ends.

FIG. 4 outlines an exemplary procedure for resource sharing according to an exemplary embodiment of this invention. In particular, control begins in step S400 and continues to step S410. In step S410, the number of latency paths are determined. Then, in step S420, the latency path information (FCI block information) is transmitted to another transceiver. Messages containing additional information can also be transmitted to the other transceiver and/or received from the other transceiver. This information can be used to, for example, assist with the determination of memory allocation in the transceiver. Moreover, the messages received from the other transceiver could specify what the memory allocation is to be based on, for example, the number of latency paths, memory allocation in the remote transceiver and required applications. Control then continues to step S430.

In step S430, and for each latency path, the steps in step 440 are performed.

In step S440, and while monitoring of allocation of resources is being performed, steps 450 and 460 are performed. More specifically, in step S450, one or more parameters associated with the communication system are determined. Then, in step S460, shared resources are allocated based on one or more of the communication parameters. Control then continues to step S470.

In step S470, the allocation of shared resources is communicated to another transceiver. Next, in step S480, a determination is made as to whether there is a change in communications that would require the adjustment of the shared resource allocation. Examples of changes in communications conditions include a change in applications being transported over the system and/or changes in the channel condition, etc. If adjustments are required, control jumps back to step S410. Otherwise, control jumps to step S490 where the control sequence ends.

The above-described system can be implemented on wired and/or wireless telecommunications devices, such as a modem, a multicarrier modem, a DSL modem, an ADSL

10

modem, an XDSL modem, a VDSL modem, a linecard, test equipment, a multicarrier transceiver, a wired and/or wireless wide/local area network system, a satellite communication system, a modem equipped with diagnostic capabilities, or the like, or on a separate programmed general purpose computer having a communications device or in conjunction with any of the following communications protocols: CDSL, ADSL2, ADSL2+, VDSL1, VDSL2, HDSL, DSL Lite, IDSL, RADSL, SDSL, UDSL or the like.

Additionally, the systems, methods and protocols of this invention can be implemented on a special purpose computer, a programmed microprocessor or microcontroller and peripheral integrated circuit element(s), an ASIC or other integrated circuit, a digital signal processor, a hard-wired electronic or logic circuit such as discrete element circuit, a programmable logic device such as PLD, PLA, FPGA, PAL, a modem, a transmitter/receiver, any comparable means, or the like. In general, any device capable of implementing a state machine that is in turn capable of implementing the methodology illustrated herein can be used to implement the various communication methods, protocols and techniques according to this invention.

Furthermore, the disclosed methods may be readily implemented in software using object or object-oriented software development environments that provide portable source code that can be used on a variety of computer or workstation platforms. Alternatively, the disclosed system may be implemented partially or fully in hardware using standard logic circuits or VLSI design. Whether software or hardware is used to implement the systems in accordance with this invention is dependent on the speed and/or efficiency requirements of the system, the particular function, and the particular software or hardware systems or microprocessor or microcomputer systems being utilized. The communication systems, methods and protocols illustrated herein can be readily implemented in hardware and/or software using any known or later developed systems or structures, devices and/or software by those of ordinary skill in the applicable art from the functional description provided herein and with a general basic knowledge of the computer and telecommunications arts.

Moreover, the disclosed methods may be readily implemented in software that can be stored on a storage medium, executed on programmed general-purpose computer with the cooperation of a controller and memory, a special purpose computer, a microprocessor, or the like. In these instances, the systems and methods of this invention can be implemented as program embedded on personal computer such as an applet, JAVA® or CGI script, as a resource residing on a server or computer workstation, as a routine embedded in a dedicated communication system or system component, or the like. The system can also be implemented by physically incorporating the system and/or method into a software and/or hardware system, such as the hardware and software systems of a communications transceiver.

It is therefore apparent that there has been provided, in accordance with the present invention, systems and methods for sharing resources. While this invention has been described in conjunction with a number of embodiments, it is evident that many alternatives, modifications and variations would be or are apparent to those of ordinary skill in the applicable arts. Accordingly, it is intended to embrace all such alternatives, modifications, equivalents and variations that are within the spirit and scope of this invention.

US 10,409,510 B2

11

The invention claimed is:

1. A method that allows sharing of hardware resources in a transceiver comprising:

allocating a first portion of shared memory to an interleaver in a first latency path; allocating a second portion of the shared memory to a deinterleaver in a second latency path,

transmitting to another transceiver information that is used to determine a maximum amount of shared memory that can be allocated to the interleaver or the deinterleaver; and

updating the shared memory allocation between the interleaver and deinterleaver based on changing communication conditions, wherein the changing communications conditions include a change in communications channel conditions.

2. The method of claim 1, further comprising transmitting to another transceiver information that that is used to determine an updated maximum amount of shared memory that can be allocated to the interleaver or the deinterleaver.

3. The method of claim 2, wherein the information is transmitted during initialization.

4. The method of claim 2, wherein the information is transmitted during SHOWTIME.

5. A system for shared memory allocation comprising: means for allocating a first portion of shared memory to an interleaver;

means for allocating a second portion of the shared memory to a deinterleaver;

means for transmitting to another transceiver information that is used to determine a maximum amount of shared memory that can be allocated to the interleaver or the deinterleaver; and

means for updating the shared memory allocation between the interleaver and deinterleaver based on changing communication conditions, wherein the changing communications conditions include a change in channel conditions.

6. The system of claim 5, further comprising means for transmitting to another transceiver information that that is used to determine an updated maximum amount of shared memory that can be allocated to the interleaver or the deinterleaver.

7. The system of claim 6, wherein the information is transmitted during initialization.

8. The system of claim 6, wherein the information is transmitted during SHOWTIME.

9. A device comprising:

first portion of shared memory allocated to an interleaver; a second portion of the shared memory allocated to a deinterleaver;

a transceiver operable to transmit to another transceiver information that is used to determine a maximum amount of shared memory that can be allocated to the interleaver or the deinterleaver; and

an allocation module operable to update the shared memory allocation between the interleaver and deinterleaver based on changing communication conditions, wherein the changing communications conditions include a change in channel conditions.

10. The device of claim 9, wherein the transceiver is further operable to transmit to another transceiver information that that is used to determine an updated maximum amount of shared memory that can be allocated to the interleaver or the deinterleaver.

11. The device of claim 10, wherein the information is transmitted during initialization.

12

12. The device of claim 10, wherein the information is transmitted during SHOWTIME.

13. A method that allows sharing of hardware resources in a transceiver comprising:

allocating a first portion of shared memory to an interleaver in a transmit latency path;

allocating a second portion of the shared memory to a deinterleaver in a receive latency path;

transmitting to another transceiver information that indicates the shared memory allocation between the interleaver and the deinterleaver; and

updating the shared memory allocation between the interleaver and deinterleaver based on changing communication conditions, wherein the changing communications conditions include a change in communications channel conditions.

14. The method of claim 13, further comprising transmitting to another transceiver information that indicates the updated shared memory allocation between the interleaver and the deinterleaver.

15. The method of claim 14, wherein the information is transmitted during initialization.

16. The method of claim 14, wherein the information is transmitted during SHOWTIME.

17. A system for shared memory allocation comprising: means for allocating a first portion of shared memory to an interleaver in a transmit latency path;

means for allocating a second portion of the shared memory to a deinterleaver in a receive latency path;

means for transmitting to another transceiver information that indicates the shared memory allocation between the interleaver and the deinterleaver; and

means for updating the shared memory allocation between the interleaver and deinterleaver based on changing communication conditions, wherein the changing communications conditions include a change in channel conditions.

18. The system of claim 17, further comprising means for transmitting to another transceiver information that indicates the updated shared memory allocation between the interleaver and the deinterleaver.

19. The system of claim 18, wherein the information is transmitted during initialization.

20. The system of claim 18, wherein the information is transmitted during SHOWTIME.

21. A device comprising:

a transceiver operable to allocate a first portion of shared memory to an interleaver in a transmit latency path and operable allocate a second portion of the shared memory to a deinterleaver in a receiver latency path;

the transceiver further operable to transmit to another transceiver information that indicates the shared memory allocation between the interleaver and the deinterleaver; and

and operable to update the shared memory allocation between the interleaver and deinterleaver based on changing communication conditions, wherein the changing communications conditions include a change in channel conditions.

22. The device of claim 21, wherein the transceiver is further operable to transmit to another transceiver information that indicates the updated shared memory allocation between the interleaver and the deinterleaver.

23. The device of claim 22, wherein the information is transmitted during initialization.

US 10,409,510 B2

13

24. The device of claim **22**, wherein the information is transmitted during SHOWTIME.

* * * * *

14